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(54) GAS TURBINE DEVICE

(71) We, KRAFTWERK UNION AKTIENGESELLSCHAFT, a German Company of Mülheim (Ruhr), Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a gas turbine device.

It has been proposed for a gas turbine to draw its combustion air from an underground air store. In such an arrangement combustion air which is accumulated in the store during times when the power requirements of the gas turbine are low is drawn from the store and fed to the combustion chamber of the gas turbine during times when a larger amount of power is required. In the arrangements of this kind the stored air is subject to fluctuating variations in conditions as a function of the amount of air in the store. Such variations in conditions are of almost adiabatic nature on filling and during extraction of air.

Such an underground store, which it is possible to form, for example, predominantly in salt deposits by flushing-out with water, also has a sump consisting of saturated brine, numerous impurities some of which contain silicic acid, and insoluble rock residues. During the frequent changes taking place relatively rapidly in the condition of the air, the degree of humidity of the air varies. In consequence of these continuous variations in pressure, temperature and humidity, it is to be expected that salt particles in the underground store will be held in a state of suspension with the stored air and, on a large amount of air being extracted, will be entrained by this air. If these particles, consisting substantially of sodium chloride or potessium chloride, penetrate into the gas turbine combustion chamber, they fuse there and are then precipitated on the low-pressure turbine blades. The coating forming in this way may result not only in constriction of the gas ducts in the blading, and thereby in greater thrust loading of the thrust bearings, but also in a diminution in power output. Additionally, the coating of salt endangers, due to intercrystalline corrosion, the strength of the rotor blading.

The invention then aims to provide a gas turbine device which is for use with an underground store of high-pressure air formed in salt deposits and which incorporates a purification device for obviating as far as possible the above-mentioned disadvantage.

According to the invention there is provided, a gas turbine device comprising:—

a hot air expansion turbine for connection to an underground store of high-pressure air formed in salt deposits;

a purification device for reducing the quantity of salt and other solid particles in the flow of air, comprising a duct which surrounds the expansion turbine and which has an end wall downstream of the expansion turbine, against which wall air from the expansion turbine impinges, in use of the gas turbine device, to be returned in the opposite direction, spin imparting means disposed in the duct for setting the air flow in the duct in helical flow so as to increase the solid particle concentration in the radial direction owing to centrifugal force, flow restriction means disposed in the duct in the path of the helical flow of air to restrict the flow of at least the air with the highest solid particle concentration, and air diverting means adjacent to, and upstream of, the flow restriction means to divert the air so restricted from the main flow of air through the duct; and

a gas turbine which is mounted on a

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shaft common to itself and the hot air expansion turbine and which is provided with a combustion chamber for increasing the air temperature of the purified air.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing in which components are illustrated in simplified, partly diagrammatic, form. In the drawing:—

Figure 1 shows one form of gas turbine device in accordance with the invention, and

Figure 2 is a view taken along the line A-A of Figure 1, showing a plurality of spin-imparting plates.

Referring to Figure 1, combustion air stored under high pressure is fed from an underground air store formed in salt deposits to the gas turbine device *via* a pipe 1, in the direction of arrow 2, and is heated in a heat exchanger 3 by the exhaust gases from a gas turbine 7. The gas turbine device together with the underground store to which it is connected constitutes a gas turbine installation. The hot air flows through a pipe 4 to an air screen 5 and from there passes to a hot air expansion turbine 6. The inlet air temperature of this expansion turbine may be selected at approximately 350°C, so that it is below the melting temperature of the salt particles. The turbine 6 is arranged, with the gas turbine 7, on a common shaft 8 which is coupled with a shaft 9 of a generator 12.

The air flow through the expansion turbine 6 is in the axial direction indicated at 10. The partially expanded air flow passing out of the turbine 6 enters the zone of spin-imparting plates 14 arranged at an end wall 13 of a duct formed by a housing 15 which contains both turbines and constitutes the air intake duct of the gas turbines: the end wall 13 closes the duct.

The plates 14 are in the form of curved blades which are radially outwardly projecting and, in Figure 2, the arrangement of these spin-imparting plates is shown more clearly. In operation, the end wall 13 and the spin-imparting plates 14 together cause the air from the expansion turbine impinging against the end wall 13 to be returned in the opposite direction and to be set, in almost surge-free manner, in rotational movement. The air then flows in the direction of arrow 16 through a space 29 between by the housing 15 and the expansion turbine 6.

The helically progressing air flow thereby set up is restricted by flow restriction means comprising a thin annular partition 17 arranged within the housing 15 and a diffuser 18 fitted into the centre of the partition. Combustion air then passes through the diffuser 18 which encloses the shaft 8 and into a chamber 19 forming the combustion chamber pre-chamber.

As this taken place, the outer marginal zone of the air flow, travelling axially towards the partition 17, accumulates at the latter and is, from there, deflected inwardly. The vortex zone thereby formed rotates in the same direction as that of the main air stream caused by the spin-imparting plates 14 and simultaneously therewith. The inlet temperature of the hot air expansion turbine is below the melting temperature of the salt particles and so they are in particulate form at the expansion turbine outlet in order that they may be centrifuged outwardly and then diverted from the air flow to the gas turbine. Thereby, the concentration of particles of salt and other impurities is increased in the radial direction due to centrifugal force and these particles migrate with the air stream towards the partition 17.

Arranged adjacent the partition 17 are air diverting means comprising suitable baffle or guide plates 20 provided in the lower zone of the partition 17, and a particle collecting chamber 21 formed in the wall of the duct adjacent the upstream side of the partition 17 and extending externally of the housing 15. The baffle plates 20 serve to deflect the air restricted by the partition 17 (and thus laden with impurities) into the chamber 21. Salt particles and foreign matter are then collected in this chamber.

In order to achieve an uninterrupted flow, the part-air flow passing through the collecting chamber 21 may be returned into the main flow at a suitable location, *via* an air filter 22, which serves to clean the air from the chamber 21, and air duct 23. Thus, for example, the pipe 23 may be connected to the housing in the zone of the diffuser 18 downstream of the partition 17. Naturally, it is also possible to discharge the part-air flow into the exhaust gas duct of the gas turbine (where the air pressure is low) so as to make available a large pressure difference for the suctional extraction of the impurities from the main air flow, the turbine exhaust duct being constituted by a section of the housing 15.

Combustion air then flows from the combustion chamber pre-chamber 19, *via* a passage 24, to a combustion chamber 25 to which (in a manner which is diagrammatically illustrated) fuel 26 is supplied together with the combustion air. The combustion chamber 25 is then followed by the gas turbine 7 having an exhaust gas duct 27 in which is arranged the heat exchanger 3 described above. The exhaust

gases leave the heat exchanger at a lower temperature in the direction of arrow 28.

It will be understood from the foregoing description that the purification device is positioned between the outlet from the hot air expansion turbine 6 and the combustion chamber pre-chamber 19 and, in the example described with reference to the drawing, comprises the components 14, 15, 17, 18, 20, 21, 22 and 23.

It will be appreciated that it is desirable for the gas turbine device to be operated in such manner that the air temperature is below the melting temperature of the salt particles until the air reaches the combustion chamber, since otherwise the purification device would not be able to perform any useful function.

WHAT WE CLAIM IS:—

1. A gas turbine device comprising:—

a hot air expansion turbine for connection to an underground store of high-pressure air formed in salt deposits;

a purification device for reducing the quantity of salt and other solid particles in the flow of air, comprising a duct which surrounds the expansion turbine and which has an end wall downstream of the expansion turbine, against which wall air from the expansion turbine impinges, in use of the gas turbine device, to be returned in the opposite direction, spin imparting means disposed in the duct for setting the air flow in the duct in helical flow so as to increase the solid particle concentration in the radial direction owing to centrifugal force, flow restriction means disposed in the duct in the path of the helical flow of air to restrict the flow of at least the air with the highest solid particle concentration, and air diverting means adjacent to, and upstream of, the flow restriction means to divert the air so restricted from the main flow of air through the duct; and

a gas turbine which is mounted on a shaft common to itself and the hot air expansion turbine and which is provided with a combustion chamber for increasing the air temperature of the purified air.

2. A gas turbine device according to claim 1, wherein the spin imparting means comprise a plurality of radially projecting, curved blades.

3. A gas turbine device according to claim 1 or 2, wherein the flow restriction means comprise an annular partition and a diffuser which is fitted into the centre of the annular partition.

4. A gas turbine device according to claim 3, wherein the air diverting means comprises a particle collecting chamber formed in the wall of the duct adjacent the upstream side of the partition and extending externally of the duct, and baffles for directing air into the collecting chamber in which the solid particles in the air so restricted are deposited in use of the purification device.

5. A gas turbine device according to claim 4, wherein the collecting chamber is connected through an air filter to the duct at a point downstream of the flow restriction mens so that, in operation, air from the collecting chamber is fed to the air filter and the clean air leaving the filter is reintroduced into the duct.

6. A gas turbine device according to any preceding claim, wherein a section of the duct constitutes an exhaust duct for the gas turbine, and a heat exchanger, which is for connection to the underground store and is connected to the inlet of the expansion turbine, is arranged in the exhaust duct to preheat the combustion air drawn from the underground store, the arrangement permitting the inlet temperature of the hot air expansion turbine to be held below the melting temperature of the salt particles.

7. A gas turbine device according to claim 5 or to claim 6 when appended to claim 5, wherein the point at which the cleaned air is reintroduced into the duct is downstream of the gas turbine.

8. A gas turbine device substantially as hereinbefore described with reference to the accompanying drawing.

9. A gas turbine installation comprising a gas turbine device according to claim 6, claim 7 when appended to claim 6, or claim 8, of which device the hot air expansion turbine is connected to the underground store by way of the heat exchanger.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

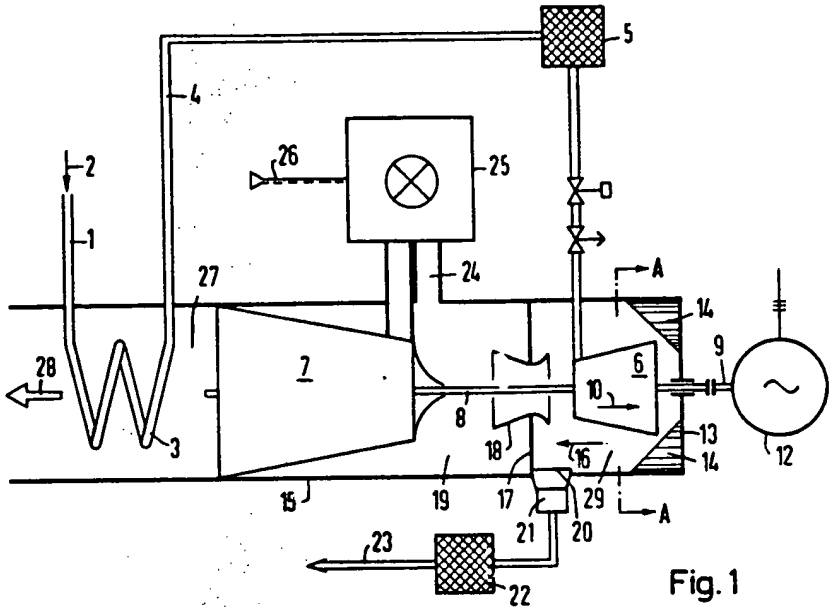

Fig. 1

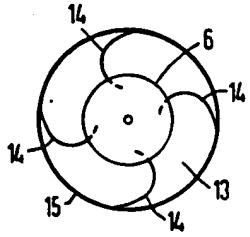

Fig. 2

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